An Evaluation of Fly Predators at Animal Farms on Leeward and Central Oahu

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This is the second part of a comprehensive study initiated by the Vector Control Branch to develop an integrated control program for nuisance flies on Oahu. The necessity for such a program was outlined in our previous paper (Toyama and Ikeda, 1975). The present study was undertaken to: (1) identify fly predators present at the farms; (2) evaluate the effectiveness of these predators in supressing fly breeding; and (3) to determine whether the predators exhibit different behavior patterns on dairy, hog, and poultry farms.

MATERIAL AND METHODS

This study was conducted from February, 1973 to August, 1974 on six poultry farms, four dairies, and four hog farms located in leeward and central Oahu. Leeward Oahu is warm and dry with rainfall occurring mostly during the winter months, while central Oahu is slightly cooler with rainfall more evenly dispersed throughout the year. The average temperature and annual precipitation for the past five years was 23.5°C. and 63.5 cm at leeward Oahu, and 23.0°C. and 75.2 cm at central Oahu.

All arthropods that were abundant in dung or carrion at animal farms were screened in the laboratory to assess their potential as predators. Field observations were then made to assess their effectiveness in the field. Laboratory tests on predation were conducted by starving the field collected insects for at least 18 hours before placing them in plastic petri dishes with the prey for a 24-hour period. There were 10 replicates each of the egg, 1st, 2nd, and 3rd instars and pupal stages of the prey. Although both adult and immature predators generally have the same feeding habits (Clausen, 1940), only adults were used in this study since very few immature predators were collected at the breeding sites.

A small piece of agar-liver medium was placed in each petri dish to provide nourishment for the prey, and also to determine whether the test species was exclusively predaceous. The medium was prepared by mixing agar with raw beef liver that had been liquified in a food blender.

Pitfall traps (Peterson, 1959) were utilized to discover nocturnal predators. The traps, which were used only at poultry farms, consisted of wide-mouthed jars that were sunk to their rims into the manure. The trap opening was protected from fresh falling dung by a jar cover roof elevated on wire leg supports soldered on the outside rim. Trials of 20 replicates each were conducted for the following baits: (1) all instars of housefly larvae consisting of several hundred per trap; (2) housefly egg clusters; (3) fresh, wet dung; and (4) empty jars. Ten replicates of each bait were placed in dry manure cones, and ten in wet manure cones. All traps were left in the manure cones for 24 hours.

An egg predation test was conducted at poultry farms to determine if egg predation by other than mites occurred. This experiment used frozen housefly egg clusters placed upon the surface of fresh dung contained in plastic drinking cups. Ten cups were placed in wet manure cones, and ten in dry cones. The egg clusters were shielded from falling dung by jar covers as with the pitfall traps. The cups were examined after 24 hours, and only those without a trace of the egg cluster bait were recorded as positive for predation.

Field predation was estimated by comparing numbers of *Musca sorbens* Wiedemann puparia reared from cow dung pats left in the field for three days, with those from pats that were brought to the laboratory to prevent predation. Losses from non-viable eggs were estimated by comparing fly populations reared from predator-excluded, laboratory-held dung pats with the numbers of eggs extracted from dung pats in the field. Weekly collections of four dung pats for each of the predator-excluded, predator-exposed, and egg samples were made for five weeks. Suitable dung pats encountered while randomly walking through the same field were collected as samples. Only fresh pats that were thinly crusted and no longer attractive for oviposition were selected for egg collection and laboratory rearing. Pats exposed to predators were collected from the same field three days after the other samples when they contained third instar larvae. Since *M. sorbens* usually pupated within four days in the summer during which this study was conducted, it was assumed that pats containing third instar larvae would be those dropped on the same day as the other samples. Attempts to use stake markers to identify the pats to be collected three days later were unsuccessful because of their destruction by cows. The collective ovipositing habit of *M. sorbens* resulted in large egg clusters which were easily extracted from the selected pats with forceps.

Results

The results (Table 1) show that many predators were not restricted to a single type of animal farm, and that the greatest variety of predators were present at poultry farms. Two predators that were consistently present at all three types of farms were the staphylinid, *Philonthus longicornis* Stephens, and the mite, *Macrocheles muscaedomesticae* (Scopoli). These species are also believed to be the most efficient predators.

The best predators under laboratory conditions were larvae of *Chrysomya rufifacies* Macquart; larvae of *Ophyra chalcogaster* Wiedemann; the staphylinid, *P. longicornis*; the histerids, *Paromalus lautus* Zimmerman and *Saprinus lugens* Erickson; the dermapterans, *Euborellia annulipes* (Lucas) and *Labidura riparia* (Pallas); the anthocorid, *Xylocoris discalis* (Van Duzee); and the mite, *M. muscaedomesticae*. Most of these species, despite showing promise in the laboratory, were not found to be efficient predators under field conditions. The performance of each species will be considered in detail in the discussion section.

Insects found on discarded, uncollected chicken carcasses at poultry farms, other than prey species, were *C. rufifacies; S. lugens*; the dermestids, *Dermestes ater* De Geer and *Dermestes maculatus* De Geer; the trogid, *Trox suberosa* Fabricius; the clerid, *Necrobia rufipes* De Geer; and the tenebrionid, *Alphitobius diaperinus* (Panzer). The Dermestidae, Cleridae, Tenebrionidae, and the Trogidae are believed to be primarily scavengers since they readily ate the liver-agar medium, while refusing, or only occasionally eating the fly larvae when denied other food. *A. diaperinus* was the most abundant beetle present at poultry farms. All stages of this species were observed congregating in large numbers under manure cones, and were believed to be responsible for much of the breakdown of the manure at the bottom of these cones. Breakdown of the manure enhanced its moisture absorbing capacity and aided in keeping the tips of the manure cones dry enough to prevent *M. domestica* breeding.

The arthropod predators associated with untrampled cow dung pats were *P. longicornis*; the histerids, *Hister bimaculatus* L., *Saprinus fimbriatus* Lec., *Atholus rothkirchi* Bickhardt, and *Pachylister lutarius* Erickson; *L. riparia*; *M. muscaedomesticae*; and the ants, *Pheidole megacephala* (Fabricius), *Solenopsis geminata* (Fabricius), and *Tetramorium simillimum* (Fr. Smith).

TABLE 2. *Potential Fly Predators Caught in Pitfall Traps at Poultry Farms*

Predator Species	*Manure condition and Bait Used*										
	Wet w/ Larvae*	Dry w/ Larvae*	Wet w/ Dung*	Dry w/ Dung*	Wet-Empty Jar*	Dry-Empty Jar*	Wet w/ Eggs*	Total w/ Larvae or Eggs	Total w/o Larvae or Eggs	Total — Wet Manure	Total — Dry Manure
Euborellia annulipes	1	4	0	11	2	4	3	8	17	6	19
Atholus rothkirchi	1	13	4	13	5	0	1	15	22	11	26
Philonthus longicornis	6	1	1	0	2	0	3	10	3	12	1
Paromalus lautus	4	1	2	4	0	0	3	8	6	9	5
Aleochara puberula	2	4	2	3	6	0	17	23	11	27	5
Labidura riparia	3	0	14	5	0	6	0	3	25	17	11
Saprinus lugens	53	13	40	12	58	18	5	71	128	156	43

*Total of Ten Replicates

Pitfall traps did not uncover any new predators, and our data (Table 2) suggested that predators which are present are inefficient in locating fly larvae. Only the Staphylinidae appeared to display definite host finding ability, while the Dermaptera and Histeridae appeared to be better at locating the host habitat than the host itself. The value of *E. annulipes* and *A. rothkirchi* as fly predators appeared to be minor as these species did not frequent the wet manure where fly larvae were concentrated.

Data summarized in Table 3 indicate that although some predation occurred, fly eggs were not particularly sought after as prey. This was particularly evident in dry manure where a low predation rate of 20% occurred, despite the presence of large numbers of potential predators. Actual egg predation, except by the mites and *P. longicornis*, was never observed under field conditions during this study.

TABLE 3. *Predation Tests on* M. domestica *Egg Clusters at Poultry Farms*

	Missing Clusters	*Intact Clusters*	*% Missing*
Wet Manure Cones	11	9	55%
Dry Manure Cones	4	16	20%

The data presented in Table 4 show that significant predation of *M. sorbens* occurred in cow dung pats. The small difference between the numbers of eggs collected from field samples, and the number of puparia reared from the protected dung pats suggests that losses due to non-viable eggs were not significant. Losses from unfavorable environmental conditions were not considered because of the healthy condition of maggots collected from the unprotected dung pats.

TABLE 4. M. sorbens *Populations in Cow Dung Pats Exposed and Unexposed to Predators*

	*Week 1**	*Week 2**	*Week 3**	*Week 4**	*Week 5**	*Range*	*Average (SD)*	*% Difference*
Eggs Unexposed Dung Pats	1887.75	5750.5	2151.5	3519.75	4681.75	383-9309	3598.25 (± 514.78)	0 %
Pupae Unexposed Dung Pats	4676.75	2781.75	4972.5	1735.0	2668.5	116-7939	3366.9 (± 442.77)	6.0%
Pupae Exposed Dung Pats	1765.75	3138.25	2152.0	2919.0	1637.5	15-4858	2322.5** (± 307.1)	31.0%

*Average of four pats per week

**Significantly Different (P = 0.05)

Although we did not detemine which predators were responsible for losses in the unprotected dung, observations indicated that *P. longicornis* and *L. riparia* were probably responsible for most of the egg and maggot predation, while histerid beetles may have accounted for most of the rest of the losses.

DISCUSSION

The results of laboratory screening of potential fly predators initially raised expectations that were not realized in the field. Repeated surveillance of the fly breeding sites showed that only a few of the species tested actively sought out the immature fly stages for prey. We observed that most of the species which readily ate the flies under laboratory conditions were, in the field, dispersed in the accumulated dung, and were seldom found in the vicinity of the areas of fly maggot concentration. From this, we concluded that the predators studied generally did not prey exclusively on flies. Even predator species which were consistently present at sites where maggots were concentrated were also found frequenting areas where no fly breeding occurred. Such dispersal of the predators strongly suggests that they utilized other food sources.

Our disappointment of finding only a few predator species was compounded by the discovery that they were also inefficient at finding their prey. Sweetman (1958) cited laboratory studies that demonstrated the inefficiency of some predators in finding prey. Our laboratory observations showed similar inefficiency among the predators which we studied. When confined in petri dishes, most of the species literally had to bump into their prey before discovering it. It was possible that the enclosed petri dishes confused the olfactory sense of these predators. Field observations and the pitfall traps indicated that the hunting ability of most of these predators may be efficient only in finding the general host habitat, while the actual finding of host individuals appeared to be a matter of chance.

The apparent inefficiency of the predators studied may have contributed to the low predation rate of the large egg masses produced by collective ovipositing habits of *M. domestica, M. sorbens, Hermetia illucens* (Linnaeus), and *Volucella obesa* Fabricus that we observed in the field. Such large concentrations of eggs would be disadvantageous to fly survival in the presence of efficient predators, but predation dependent upon chance encounters may so limit the number of predators able to find eggs that these would have relatively little impact on fly population levels. Although reasons for collective oviposition by these flies were not determined, this habit appeared to have some survival value for these species.

Field observations at poultry farms showed that houseflies laid their eggs on the drier perimeter of wet areas in the manure. Apparently, manure must be in a certain optimum condition before oviposition occurs since most of the larvae observed in isolated wet spots in manure were usually in the same stage of development. This uniformity of age suggests that most eggs were deposited within a short period of time.

The stratiomyid, *H. illucens*, and the syrphid, *V. obesa*, preferred to deposit their eggs in elevated dried material surrounding semi-liquid poultry manure. Oviposition occurred either in the dried manure, on support pillars for cages, or along the edges of dung accumulated on the concrete blocks used as bases for the support pillars. The chalky-white eggs of *V. obesa* were deposited several layers thick, and sometimes covered an area as large as 7.6 cm X 15 cm on the pillar posts. *H. illucens* oviposited along the top edges of the concrete blocks, often creating a straw-colored ribbon of eggs along the perimeter of the blocks.

M. sorbens, which bred only in untrampled cow dung pats, also deposited its eggs in large clusters. The tremendous numbers of eggs which are often deposited was demonstrated when the eggs were counted in a dung pat that was particularly attractive to the flies. This pat contained four large custers with 1491, 1043, 2961, and 1519 eggs, respectively, and three smaller clusters with a combined total of 2040 eggs; a grand total of 9054 eggs for the pat. Fortunately, such heavy oviposition occurred only during the summer months of the two years we observed this species.

In addition to the habit of massed oviposition, the protective mechanisms of a very short egg stage in *M. sorbens* and an apparently distasteful quality in the eggs of *H. illucens* were also observed. During the warmer summer months, egg clusters of *M. sorbens* were found hatching by late afternoon of the same day they were deposited, and were therefore exposed to predation for a relatively very short time. Apparent unacceptability of *H. illucens* eggs to predators was discovered during tests conducted to determine the predators of this species. These showed that most predators which were voracious feeders on housefly eggs refused to eat those of *H. illucens*, even when starved. When these same predators were offered a choice between housefly and soldier fly eggs, they invariably consumed only the former. The only predators that attacked the soldier fly egg were the mite, *M. muscaedomesticae*, and the anthocorid, *X. discalis*. In the laboratory the predators, *S. lugens* and *L. reparia*, ate the internal parts of the soldier fly larvae, but whether they would do so under field conditions was not determined.

Ants were observed to prey only on fly larvae confined in shallow wooden boxes filled with dung and larvae, which we used as pupal receptacles on animal farms during our study on fly parasites. The boxes were occassionally raided by *P. megacephala* or *S. geminata*, and these two species often reduced larval populations known to be well over a thousand, to less than a hundred. Our observations indicated that intense predation of fly larvae by ants is not usual on animal farms. Workers of *S. geminata* and *P. megacephala* which we observed returning to the nests were only seen carrying pieces of grain from spilled animal feed. Foraging workers were observed frequently walking over fly maggots in the dung without attacking them. A minor experiment that we conducted seemed to indicate that these two species become predatory only under certain conditions. We arrived at this conclusion after healthy maggots dropped directly on a busy *P. megacephala* trail were ignored by the ants. Crushed dead maggots also produced little response, but maggots injured by crushing with a pair of forceps were quickly attacked.

Our observations also showed that once an attack on an injured maggot occurred, any healthy maggot dropped in the vicinity was also attacked. From these observations, it appeared that the value of ants as fly predators on animal farms may be very limited.

The larvae of the muscid, *O. chalcogaster*, and the calliphorid, *C. rufifaces*, which were mentioned by Bohart and Gressitt (1951) as being predacious, were the only Diptera larvae tested. Observations of *C. rufifacies* in chicken carrion showed that they were never present in sufficient numbers to be effective as predators. This was demonstrated by the number of puparia recovered in the wooden boxes with chicken carrion, used for our study of fly parasites, which yielded 8533 *P. cuprina* to only 282 *C. rufifacies*.

The larvae of *O. chalcogaster*, which also showed great potential in the laboratory, seemed to be of little value in poultry manure since they were never found in the same areas as housefly larvae. This species preferred moist but firm tips of manure cones where housefly larvae never occurred. Larvae of *O. chalcogaster* and *C. rufifacies* were not dependent on predation for survival and exhibited no cannibalistic tendencies in the laboratory.

The mite, *M. muscaedomesticae*, was the most important predator of fly eggs in accumulated dung on Oahu, but appeared to be of little value against *M. sorbens* eggs in fresh dung pats. The mites were never present in quantity on dung pats on the critical first day before the eggs hatch. *M. muscaedomesticae* obviously destroys many fly eggs, but it is doubtful whether it has the ability to completely control fly breeding by itself. Aside from not being present in sufficient numbers at egg clusters examined in the field, the efficiency of the mites appeared to be inhibited by their feeding habits, and by the egg-laying habits of the flies. Mite feeding by piercing and sucking caused fly eggs to collapse, leaving shells which became dry and hard. These collapsed eggs eventually formed a barrier on the surface of egg clusters which appeared to protect the eggs in the center from further predation. Examination of housefly eggs in the field showed some clusters which outwardly appeared to be composed of dried shells, but which contained intact fly eggs in the center portion. Since most of the eggs in the central portion were deposited before the eggs surrounding them, it seemed unlikely that they would hatch after the surface eggs. It was therefore concluded that the surface eggs were probably victims of predation.

Of the seven histerid beetles present at animal farms, only one species, *P. lautus*, was abundant. This tiny histerid (2 mm), which was numerous only in poultry manure, showed promise as an egg predator in the laboratory, but was not effective in the field. The largest histerid, *P. lutarius* (15 mm) was found only in isolated cow dung pats in the field. This species was never abundant, and its effectiveness as a predator was probably minimal. *S. lugens* was the only carrion frequenting species and was usually found on chicken carrion or walking on wet manure containing *M. domestica* larvae. *S. lugens* was consistently found preying on fly larvae at poultry farms, but was too scarce to be effective. Due to their inadequate numbers, the histerids were considered ineffective as fly predators at animal farms on Oahu.

The staphylinids were represented by one species which was consistently present at all three types of animal farms in sufficient numbers to be considered an effective predator. This species, *P. longicornis*, was especially valuable against *M. sorbens* at dairies because of its mobility among the pats. This diurnal species was one of the few that attacked fly eggs under pastureland conditions. *P. longicornis* preyed upon all stages of the flies including adults that alighted on the dung. Adults of *Aleochara puberula* Klug., which is a parasite during its larval stage on *M. domestica* pupae (Toyama and Ikeda, 1976), may also be effective predators in accumulated dung, particularly at dairies. Catches from pitfall traps baited with eggs indicated that this species probably preys upon fly eggs in the field. Eighteen other species of staphylinids were collected at the animal farms, but they were not considered in this study since they were infrequently encountered. The Staphylinidae are probably next in importance to the mites as fly predators at animal farms.

Two earwigs, *E. annulipes* and *L. riparia*, were the only Dermaptera found consistently at animal farms. While *E. annulipes* was an effective predator in the laboratory, field observations and the pitfall traps indicated that they may not be effective fly predators in the field. This species was found abundantly only in dry manure where no fly breeding occurred. The large (25 mm) *L. riparia* were usually found at dairy farms under dung pats. This species was especially vicious and killed or mutilated without devouring their prey in laboratory tests. In the laboratory *L. riparia* also exhibited scavenger habits by consuming liver-agar medium and dead *Onthophagus* beetles. It also preyed on adults of the dung beetle, *Aphodius lividus* (Oliver), as well as housefly larvae in the laboratory. The efficiency of these largely nocturnal predators was not determined during this study.

The only hemipteran predatory on immature flies under laboratory conditions was the anthocorid, *X. discalis*. This tiny species (2 mm) fed on eggs and all stages except the third larval instar and pupae. We have observed this species attempting to feed on third instar fly larvae in the laboratory, but it was always dislodged by maggots of this stage whenever it attempted to feed. This predator, which was fairly abundant at poultry farms and to a lesser extent in accumulated manure at the dairies, was never observed preying upon fly larvae under field conditions.

Onthophagus gazella Fabricius, *Onthophagus sagittarius* Fabricius, and *A. lividus* were the only dung beetles commonly found on individual dung pats at dairies. The large *Copris incertus prociduns* Say and the smaller *Oniticellus cinctus* (F.) were rarely found and are probably of little value as dung feeders at dairies. The beetles we observed did an excellent job of eliminating dung pats in pastures, but did not appear to be as effective in suppressing fly breeding. *M. domestica* was rarely found in individual dung pats on Oahu and *M. sorbens* usually left the dung to pupate before the pats were destroyed by the beetles. The dung beetles and *M. sorbens* larvae appeared to co-exist in almost all the dung pats examined without obvious detriment to the flies, since maggots in older pats were full-sized and showed no ill effects from competition.

While it was difficult to assess each predator's role in the reduction of fly populations under natural conditions, our limited observations indicated that the most valuable predators at present on Oahu appear to be *P. longicornis* and *M. muscaedomesticae*. The value of the mite was greatest in accumulated

manure while the staphylinid was most effective on isolated dung pats under pasture conditions. *L. riparia* may be an effective predator but we could not establish that its primary prey are fly larvae. Excluding the ants, the only confirmed predators of fly larvae under field conditions were *P. longicornis, M. muscaedomesticae, P. lutarius,* and *S. lugens,* while the unconfirmed but suspected predators were *A. puberula* and *L. riparia.*

CONCLUSIONS

From this study we have concluded that: (1) most, if not all, of the predators studied were not specific in their prey selection; (2) only a few species were responsible for most predation; (3) the predators studied were generally inefficient at finding fly larvae; (4) flies possessed mechanisms which reduced the effectiveness of predators; and (5) predator behavior under laboratory conditions could not be assumed to be the same as under natural field conditions.

This study has shown that the predators possess the potential to eliminate a significant portion of fly larvae on animal farms despite barriers to predation and the limitations in their abilities. The conclusion reached after assessing the biological control agents thus far, is that fly control programs on Oahu must be integrated programs in which water management is given first priority (Toyama and Ikeda, 1976), and chemical treatments are limited to spot treatments of larval breeding sites with non-residual insecticides when conditions of excessive fly breeding occur.

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A New Species and New Records of *Dasyhelea* from the Tonga Islands and Samoa (Diptera: Ceratopogonidae)

WILLIS W. WIRTH[1]

I am very much indebted to Dr. James C. Hitchcock, Jr., of the World Health Organization for the opportunity to study a long series of *Dasyhelea* midges that he collected during surveys for mosquitoes involved in filaria transmission in the Tonga Islands. I am also grateful for his permission to deposit the types in the collection of the U.S. National Museum. Paratypes are deposited in the B.P. Bishop Museum, Honolulu, the Australian National Collection in Canberra, and the British Museum (Natural History) in London.

An explanation of the terminology used and a diagnosis of the genus *Dasyhelea* Kieffer is given in an earlier publication (Wirth, 1952). Williams (1944) gave a detailed and splendidly illustrated account of the biology and immature stages of the Hawaiian species in an earlier number of these Proceedings.

Dasyhelea hitchcocki Wirth, new species (fig. 1).

Allotype female.—Wing length 1.13 mm; breadth 0.46 mm.

Head: Brown. Frontal sclerite as in fig. 1d. Antenna (fig. 1a) brown, flagellum with lengths of segments in proportion of 35-30-32-32-33-35-35-38-40-40-40-40-55, antennal ratio 0.72; verticils relatively long and stout; proximal antennal segments with prominent reticulations on proximal halves, distal five segments with reticulations covering entire length. Paplus (fig 1b) with lengths of four distal segments in proportion of 20-38-18-22; antepenultimate segment short and moderately stout, length to width ratio 2.4, with a few scattered sensilla.

Thorax: Appearing dark brown in alcohol and slide-mounted specimens; pollinose pattern not discernible. Mesonotum covered with numerous, suberect, moderately stout, hairlike setae. Scutellum brown, with numerous coarse setae. Legs pale yellowish, narrow knee spots dark brown; moderately broad brownish median bands on all femora and tibiae; narrow apices of fore femur and tibia brownish. Legs from femora to tarsi provided with abundant, moderately stout bristly setae, some of which on extensor side of tibiae are much longer and bristlelike. Sclerotized bridge between fore coxae (fig. 1e) with prominent, pointed, pubescent, lateral processes. Wing (fig. 1c) with costa attaining 0.46 of wing length; radial cells elongate; wing surface grayish due to coarse microtrichia; macrotrichia long and abundant over entire wing. Halter brownish infuscated.

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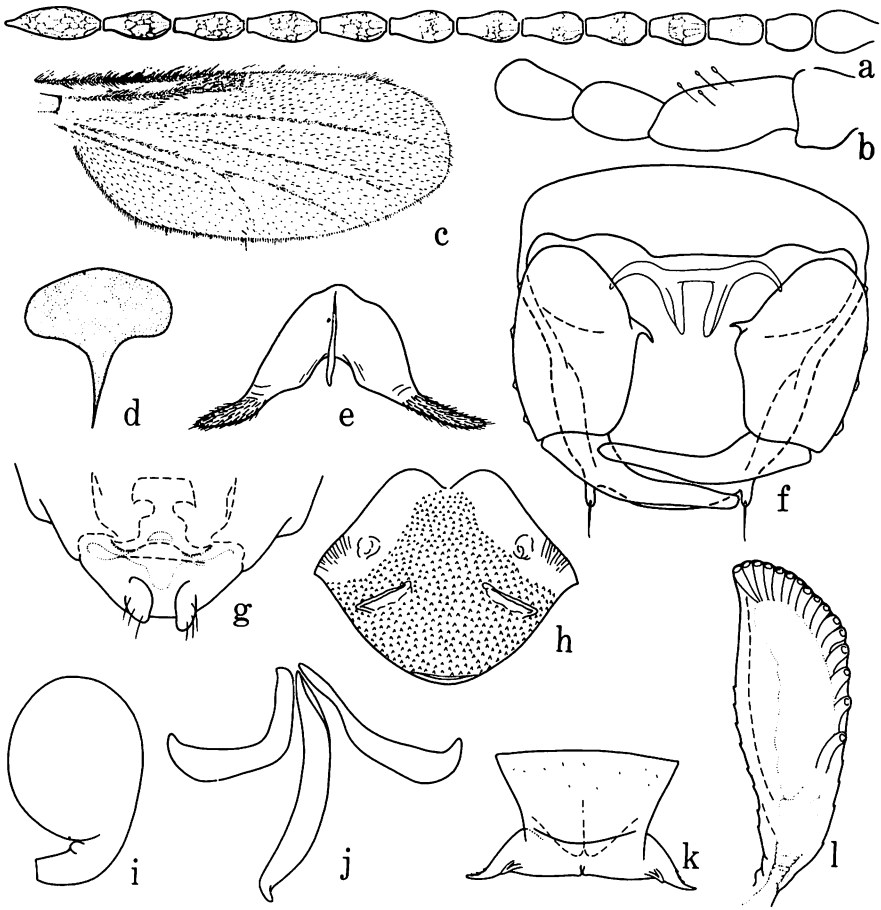

FIG. 1. *Dasyhelea hitchcocki:* a, female antenna; b, female palpus; c, female wing; d, female frontal sclerite; e, female coxal bridge; f, male genitalia, parameres removed; g, female subgenital plate; h, pupal operculum; i, female spermatheca; j, male parameres; k, pupal abdomen, caudal segment; l, pupal respiratory horn.

Abdomen: Dark brown, without apparent segmental pale bands; provided with abundant appressed hairlike setae, evenly distributed and not arranged in streaks or blotches. Subgenital plate (f9g. lg) constricted in midportion, anterior lobe transversely quadrate, lateral arms moderately slender. Spermatheca (f9g. 1i) one, ovoid with stout, curved neck causing retort-shaped appearance; measuring 0.061 by 0.051 mm exclusive of neck, latter 0.024 mm long and 0.016 mm in greatest diameter.

Holotype male.—Wing length 1.17 mm; breadth 0.38 mm.

As in female with usual sexual dimorphism; color as in female. Costa attaining 0.48 of wing length. Antenna with lengths of flagellar segments in proportion of 35-28-28-28-28-30-30-30-30-72-60-46-70. Genitalia (fig 1f) with ninth sternum transverse, not produced over base of aedeagus; ninth tergum short, moderately tapering with caudal margin truncate and bearing a pair of short, inconspicuous apicolateral processes. Basistyle stout, about twice as long as broad, with a small hooklike process near midlength on mesal margin; dististyle long and slender, slightly curved in midportion, tapering to slender tip. Aedeagus with slender, transverse basal bridge, lateral arms curving slightly caudad; bearing a pair of small, simple, posterior processes with rounded apices. Parameres (fig 1j) asymmetrical, basal apodemes curved and moderately stout, the posterior median process slightly curved, moderately stout, tapering to a small, ventrally bent, distal point.

Pupa.—Integument yellowish brown, with inconspicuous spicules and shagreening. Respiratory horn (fig. 1L) short and broad, with apex broadly rounded, slightly longer on anterior side, and bearing a distal row of 16 spiracular papillae continuing about halfway to base on posterior side. Operculum (fig. 1h) with anterior margin rounded and bearing a distinct marginal thickening; lateral tubercles each in form of a low transverse carina, without seta; surface of operculum on anterior and midportions with coarse, sharp denticles. Abdominal segments provided with well-developed processes on caudal margins, short and rounded on mesal portion but greatly elongated and pointed on sides of segments; processes each with minute hyaline seta. Caudal segment (fig. 1k) with pair of apicolateral processes directed laterad and curved and tapering to sharp apices; subapical tubercles poorly developed.

Distribution.—Tonga Islands.

Types.—Holotype, male, Tafahi Island, Kolokokala, 28 July 1970, J.C. Hitchcock, reared from rock hole, with pupal exuviae (Type no. 69482, USNM). Allotype, female, same data but 30 July 1970, reared from tree hole in Fau tree (*Hibiscus tiliaceus* L.—Malvaceae). Paratypes, 7 males, 9 females, with pupal exuviae and associated larvae, all collected by J.C. Hitchcock in Tonga: same data as holotype, 2 males, 3 females (113A); same data as allotype, 1 male, 1 female (8A). Niuatoputapu Group: Motualango Island, Hihifo, 23 August 1970, reared from tree hole in Puopua tree (*Gueharda speciosa* L.—Rubiaceae) (241A), 1 female; Nukunono Island, reared from tree hole in Fau tree (245A), 2 males, 1 female; Niuatoputapu Island, Hihifo, 26, 28 August 1970, reared from step cut in coconut tree (*Cocos nucifera* L.—Palmae) (270A), 2 males, 2 females. Niuafo'ou Islands: Futu, 24 September 1970, reared from tree hole in mango tree (*Mangifera indica* L.—Anacardiaceae) (305A), 1 female.

Discussion.—*Dasyhelea carolinensis* Tokunaga from the Carolines, Samoa, and Tonga is similar to *D. hitchcocki* but the former can be distinguished readily by its unbanded or indistinctly banded dark legs; the spermatheca with slender, straight neck; the long, reflexed, distal portion of the male parameres; the apicolateral processes on the male ninth tergum longer and more divergent; and the mesal hooklike processes absent on the male basistyle. In the pupa of *D. carolinensis* the respiratory horn is much longer and slender, expanded distally, with a marginal series of more than 30 spiracular papillae; the lateral spines on the abdominal segments are short and blunt with margins more or less rounded; and the apical processes of the caudal segment are short, each with three lobes directed caudad.

Dasyhelea assimilis (Johannsen, 1931), reared from bamboo stumps in Indonesia, is also closely related to *D. hitchcocki*. A series of *D. assimilis* in the U.S. National Museum collection, reared by W.W. McDonald from a bamboo internode at MP 15 Ulu Gombak Road, Malaya, has the legs paler than in *D. hitchcocki* with small dark knee spots and narrow median dark bands on femora and tibiae; the neck of the spermatheca is much stouter, the pupal respiratory horm is more slender with only about 10 papillae, and the apical processes of the pupal caudal segment are directed caudad, more sharply pointed, and bearing a few small subapical spinules (figured by Mayer, 1934).

Dasyhelea carolinensis Tokunaga

Dasyhelea carolinensis Tokunaga, 1941: 112 (male; Truk Islands); Tokunaga and Murachi, 1959: 283 (male, female redescribed; fig. wing, antenna, palpus, genital sclerite, specmatheca, male genitalia; recorded from Palau, Truk, Ponape in Caroline Islands).

New Records.—SAMOA: Pago Pago, 10 Feb. 1957, W.R. Kellen, 4 males, reared, with pupal exuviae. TONGA: Niuafo'ou Island, Futu, 24 Sept. 1970, J.C. Hitchcock, reared from rock hole by sea shore (302A), 1 male, 3 females; same data but no. 309, 1 female.

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